# CBU-610 Capacitor Blocking Unit Technical Manual

COOPER Power Systems

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# SAFETY FOR LIFE

Cooper Power Systems products meet or exceed all applicable industry standards relating to product safety. We actively promote safe practices in the use and maintenance of our products through our service literature, instructional training programs, and the continuous efforts of all Cooper Power Systems employees involved in product design, manufacture, marketing, and service.

We strongly urge that you always follow all locally approved safety procedures and safety instructions when working around high voltage lines and equipment and support our “Safety For Life” mission.

# SAFETY INFORMATION

The instructions in this document are not intended as a substitute for proper training or adequate experience in the safe operation of the equipment described. Only competent technicians, who are familiar with this equipment should install, operate, and service it.

A competent technician has these qualifications:

- *Is thoroughly familiar with these instructions.*
- *Is trained in industry-accepted high and low-voltage safe operating practices and procedures.*
- *Is trained and authorized to energize, de-energize, clear, and ground power distribution equipment.*
- *Is trained in the care and use of protective equipment such as flash clothing, safety glasses, face shield, hard hat, rubber gloves, hot stick, etc.*

Following is important safety information. For safe installation and operation of this equipment, be sure to read and understand all cautions and warnings.

## Hazard Statement Definitions

This document may contain three types of hazard statements:

**DANGER:** Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

**WARNING:** Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

**CAUTION:** Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury or equipment damage.

**CAUTION:** Indicates a potentially hazardous situation which, if not avoided, may result in equipment damage only.

## Safety Instructions

Following are general danger and warning statements that apply to this equipment. Additional statements, related to specific tasks and procedures, are located throughout the document.

**DANGER:** Hazardous voltage. Contact with hazardous voltage will cause death or severe personal injury. Follow all locally approved safety procedures when working around high and low-voltage lines and equipment. G103.3

**DANGER:** Before installing, operating, maintaining, or testing this equipment, carefully read and understand the contents of this document. Improper operation, handling, or maintenance can result in death, severe personal injury, and equipment damage. G101.0

**DANGER:** This equipment is not intended to protect human life. Follow all locally approved procedures and safety practices when installing or operating this equipment. Failure to comply may result in death, severe personal injury, and equipment damage. G102.1

**DANGER:** Power distribution and transmission equipment must be properly selected for the intended application. It must be installed and serviced by competent personnel who have been trained and understand proper safety procedures. These instructions are written for such personnel and are not a substitute for adequate training and experience in safety procedures. Failure to properly select, install, or maintain power distribution and transmission equipment can result in death, severe personal injury, and equipment damage. G102.1

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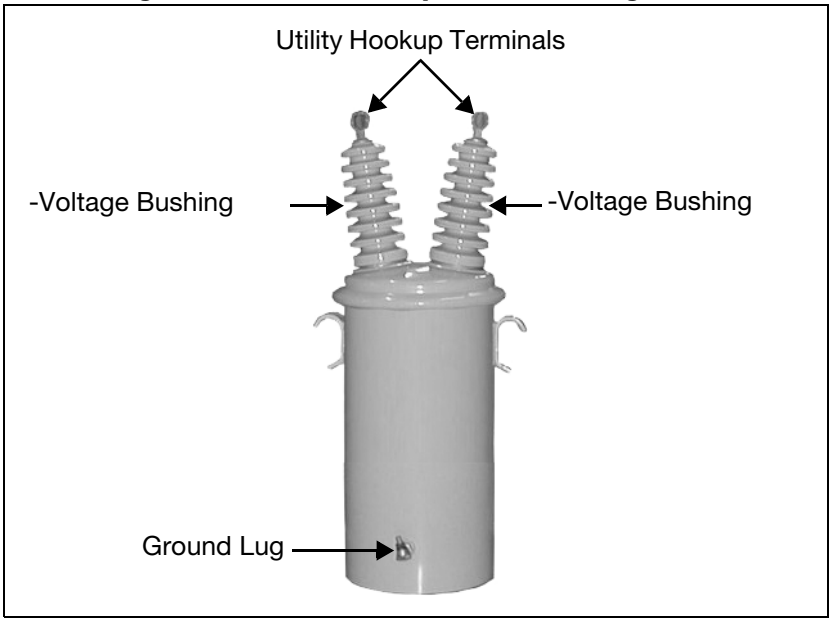
# Chapter 1
# CBU-610 Capacitor Blocking Unit Overview

## 1.1 Introduction

This document contains the field installation and maintenance instructions for the CBU-610 Capacitor Blocking Unit. The CBU-610 is designed for use with Cooper Power Systems' Power Line Carrier (PLC) communications system.

A CBU-610 is installed at capacitor banks to prevent power line carrier signal losses through the capacitors to ground or from line to line. A three-phase wye-connected capacitor bank, made up of double or triple bushing capacitors, may be blocked with a single CBU in the neutral circuit. Additional CBUs may be required to effectively block capacitor banks with single bushing capacitors, delta-connected capacitor banks, or other situations as described in this manual.

**Figure 1.1 CBU-610 Capacitor Blocking Units**




The instructions in this manual are arranged in the normal sequence of events. When the CBU-610 is installed and operational, the individual procedures may be performed as required to maintain the CBU.

This manual is divided into the following sections:

- Chapter 1, "CBU-610 Capacitor Blocking Unit Overview"
- Chapter 2, "CBU-610 Installation"

## 1.2 CBU-610 Description

The CBU-610 is a high impedance inductor that prevents PLC signals from being shunted to ground when wye-connected capacitor banks are on the distribution lines, as shown in “One CBU in a Three-Phase Wye Configuration” on page 6. The CBU also prevents PLC signals from being shunted line to line when delta-connected capacitor banks are on the distribution line, as shown in “Three CBUs in a Three-Phase Delta Configuration” on page 7.

**NOTE:** The CBU-610 provides a low impedance to the 50-60 Hz power frequency, which prevents it from altering the operation of the capacitor banks.

Typically, the distribution lines are three-phase and capacitor banks are used in all three phases. Therefore, the CBU installation must also be effective in all three phases.

- Multiple CBUs are needed to block capacitor banks that are made up of single-bushing capacitors. The CBUs are installed in each phase between the capacitor bank and the primary (high) side of the distribution line.
- A single CBU is needed to block wye-connected capacitor banks that are made up of double-bushing or triple-bushing capacitors. In some instances, a single CBU does not provide the best communication conditions. In this case, CBUs must be installed on the individual phases to improve communication, as described in “Three CBUs in a Three-Phase Wye Configuration” on page 7.
- Three CBUs are needed to block delta-connected capacitor banks that are made up of double-bushing or triple-bushing capacitors. The CBUs are installed between the capacitor banks to prevent PLC signal from being shunted line to line.

With any of the above configurations, the nominal current rating of the CBU, shown in “1.2.2 CBU-610 Styles” on page 3, must be equal to or greater than the phase current of the capacitor bank. To determine the style/size of the CBU to install, see “2.1.2 Determining the Correct CBU Size” on page 8.

### 1.2.1 CBU-610 Hardware Specifications

The hardware specifications of the CBU are displayed in the following list:

- Hanger:
  - Standard NEMA
- Operating Range:
  - Temperature: -40 °F to +131 °F (-40 °C to +55 °C)
  - Humidity: 0 to 100% (condensing)
- Fault Current Rating:
  - 50 to 60 Hz, 25 kA crest 3 cyc
  - IEEE 28 kA 8 x 20g sec wave

The typical kVAR ratings of a CBU in a three-phase installation are shown in “1.2.3 Typical Three-Phase CBU-610 kVAR Ratings” on page 3.

### 1.2.2 CBU-610 Styles

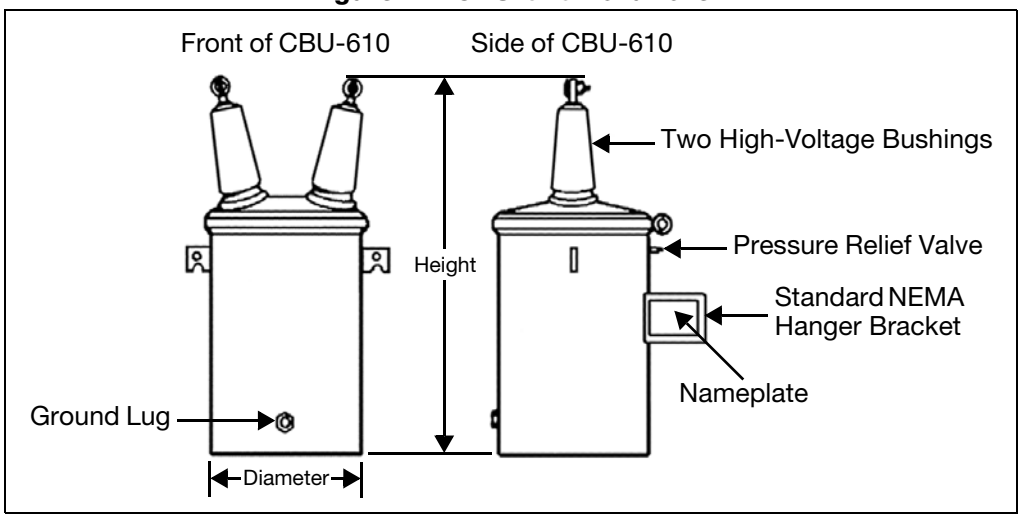
The ampere rating on the nameplate of each CBU style takes into account fluctuations in system voltage and variances in the capacitance of individual capacitor banks. These differences can result in more current flowing in a CBU than was calculated for the application. However, the CBU nameplate ampere rating is not the maximum current rating; it is the nominal current rating instead. The specifications of each CBU style, including the nominal and maximum current rating, are displayed in Table 1.1.

**Table 1.1 CBU-610 Style Specifications**

| Style Number | Nominal Current Ratings (A) | Maximum Current Ratings (A) | Nominal Inductance (MHz) | BIL (kV) | Diameter | Height | Weight |
|---|---|---|---|---|---|---|---|
| CB01PX01 | 30 | 40 | 6 | 125 | 10.25 in. (26 cm) | 27.25 in. (69 cm) | 95 lb. (43 kg.) |
| CB02PX01 | 60 | 81 | 3 | 125 | 10.25 in. (26 cm) | 32.75 in. (83 cm) | 142 lb. (64.4 kg.) |
| CB03PX01 | 85 | 114 | 3 | 150 | 13.0 in. (33 cm) | 32.75 in. (83 cm) | 180 lb. (81.6 kg.) |

The hardware features of the CBU are displayed in Figure 1.2.

**Figure 1.2 CBU-610 Hardware**




### 1.2.3 Typical Three-Phase CBU-610 kVAR Ratings

The typical kVAR ratings of a CBU in a three-phase installation are displayed in Table 1.2.

**Table 1.2 CBU-610 kVAR Ratings**

| CBU STYLE | 4.16 kV | 12.47 kV | 13.8 kV | 24.9 kV | 34.5 kV |
|---|---|---|---|---|---|
| CB01PX01 | 150 | 600 | 600 | 1200 | 1800 |
| CB02PX01 | 300 | 1200 | 1200 | 2400 | 3600 |
| CB03PX01 | 450 | 1800 | 1800 | 3600 | 5400 |

- All voltages expressed as nominal line-to-line RMS.
- 125 kV BIL may not be acceptable without additional lightning protection if the CBU is installed in the primary.

# Chapter 2
# CBU-610 Installation

This chapter describes how to install, test, and initialize a CBU-610 Capacitor Blocking Unit and it is divided into the following sections:


- “2.1 CBU-610 Installation Preparation” on page 6
- “2.2 CBU-610 Installation Steps” on page 13
- “2.3 Testing the CBU-610 Installation” on page 15
- “2.4 Removing the CBU-610” on page 15

## 2.1 CBU-610 Installation Preparation

The following sections describe the procedures that must be performed to prepare for a CBU installation:


- "Determining the CBU Installation Location" on page 6
- "Determining the Correct CBU Size" on page 8


### 2.1.1 Determining the CBU Installation Location

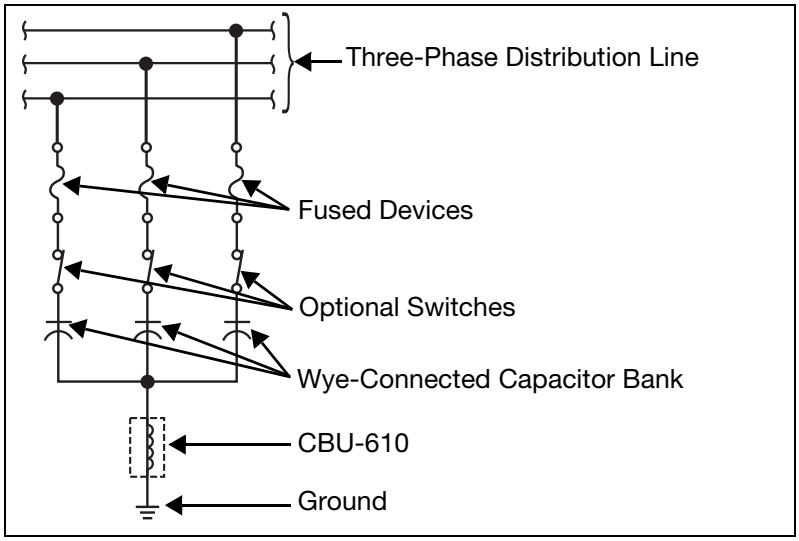
The installation location of the CBU depends on the type of capacitor bank configuration in which it is being installed:


- "One CBU in a Three-Phase Wye Configuration" on page 6
- "Three CBUs in a Three-Phase Wye Configuration" on page 7
- "Three CBUs in a Three-Phase Delta Configuration" on page 7
- "One CBU in a Single-Phase Configuration" on page 8


#### One CBU in a Three-Phase Wye Configuration

The configuration shown in Figure 2.1 is a three-phase wye configuration connected to a capacitor bank with double-bushing or triple-bushing capacitors. For this type of configuration, a single CBU is installed between the capacitors and ground.

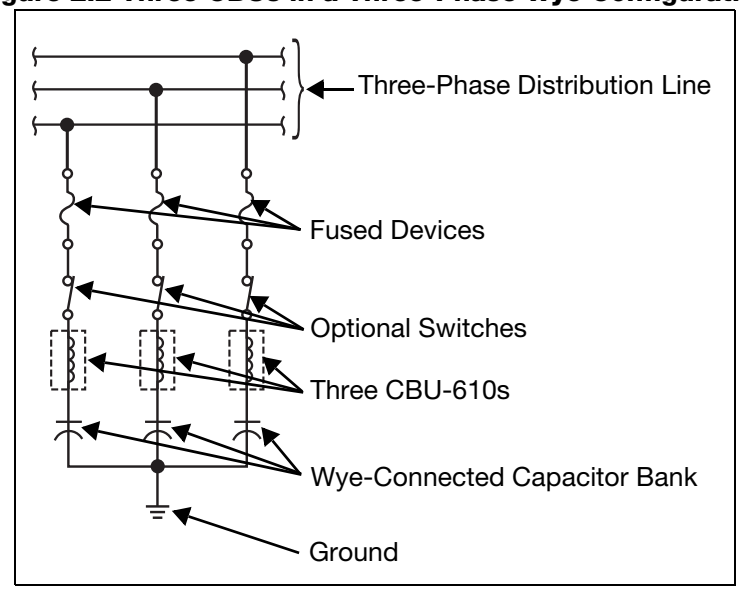
**Figure 2.1 One CBU in a Three-Phase Wye Configuration**



## Three CBUs in a Three-Phase Wye Configuration

The configuration shown in Figure 2.2 is a three-phase wye configuration connected to a capacitor bank with double or triple-bushing capacitors. In some instances, a single CBU does not provide the best communication conditions for this type of configuration. Therefore, three CBUs may need to be installed between the capacitors and the primary (high) side of the distribution line to prevent the PLC signal from shunting line to line.

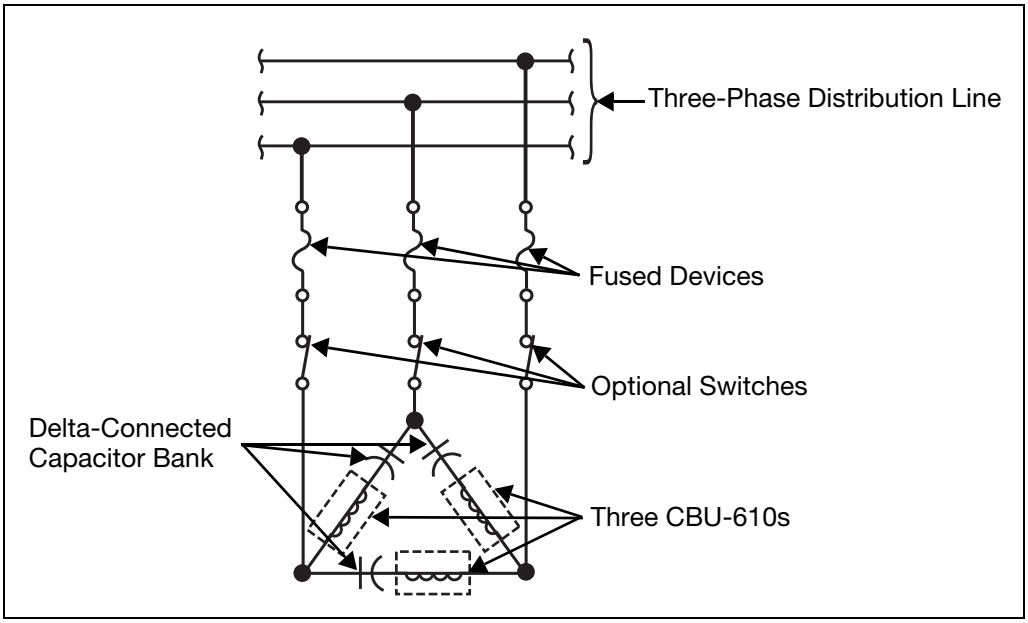
**Figure 2.2 Three CBUs in a Three-Phase Wye Configuration**




## Three CBUs in a Three-Phase Delta Configuration

The configuration shown in Figure 2.3 is a three-phase delta configuration connected to a capacitor bank with double or triple-bushing capacitors. For this type of configuration, three CBUs are installed to isolate the capacitors from each other and prevent PLC signal from shunting line to line.

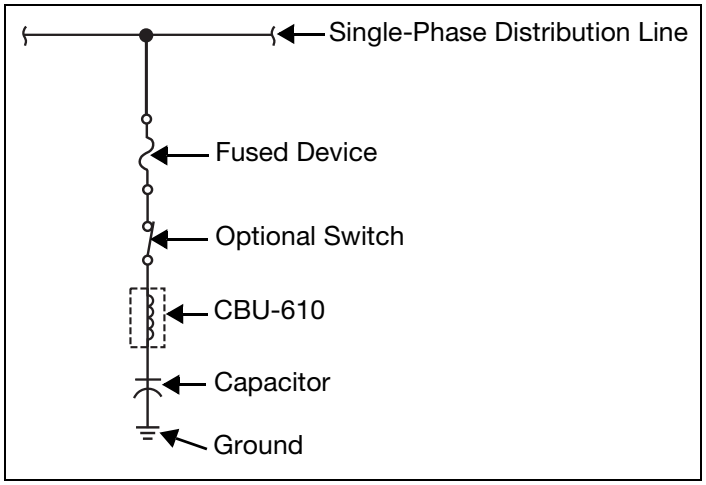
**Figure 2.3 Three CBUs in a Three-Phase Delta Configuration**



### One CBU in a Single-Phase Configuration

The configuration shown in Figure 2.4 is a single-phase configuration connected to one single-bushing capacitor bank. For this type of configuration, a single CBU is installed between the capacitors and the primary (high) side of the distribution line.

**Figure 2.4 One CBU in a Single-Phase Configuration**




## 2.1.2 Determining the Correct CBU Size

The following sections describe how to determine the size of the CBU-610 that is needed for different capacitor bank configurations. The correct size of a CBU is based on the kVAR rating and voltage of the capacitor bank.

- “Size of One CBU in a Three-Phase Wye Configuration” on page 9
- “Size of Three CBUs in a Three-Phase Wye Configuration” on page 10
- “Size of Three CBUs in a Three-Phase Delta Configuration” on page 11
- “Size of One CBU in a Single-Phase Configuration” on page 12

If the capacitor bank configuration is different than the configurations described above, contact Cooper Power Systems’ customer service at 1-800-815-2258 for help with calculating the correct CBU size.

## Size of One CBU in a Three-Phase Wye Configuration

When one CBU is installed between the capacitors and the ground of a three-phase wye configuration, as shown in Figure 2.1 on page 6, the operating current of the CBU is calculated by dividing the size of the capacitor bank by the line to ground voltage.

### Example

This example shows how to calculate the correct size for one CBU in a three-phase wye configuration.

1. Take the size of the capacitor bank, which is 600 kVAR (600,000 VAR) in this example.

$$600 \times 1000 = 600000$$

2. Calculate the current by dividing the result of step 1 by the line to ground voltage, which is 12.47 kV (12,470 V) in this example.

$$\frac{600000}{12.47 \times 1000} = 48.1$$

3. The calculated current is 48.1 A. As shown in Table 1.1 on page 3, this value is below the nominal current rating of CBU style CB02PX01, which is 60 A.

**NOTE:** 60 A CBUs (CB02PX01) will work for three-phase wye configurations that are 12.47 kV or higher, if the capacitor bank is 600 kVAR or smaller.
A decrease in voltage or increase in kVAR will cause the current to increase, which will require the use of the 85 A CBU (CB03PX01).

### Important Note

When a single CBU is installed in the neutral of a three-phase wye configuration, the operating current of the CBU is low (theoretically zero). In reality, there is unbalance in the three phase voltage and in the capacitance of the three phase capacitor bank that creates a non-zero neutral current. Using this analysis, there is a possibility of applying a CBU in the neutral that has a significantly lower ampere rating than the each individual capacitor's single-phase current rating.

However, a problem can occur if the capacitor bank is subjected to a transient that opens one of the phases. Then, current equal to the capacitor bank single-phase rating flows through the CBU. If this condition exists for more than a few hours, there is a significant possibility that the underrated CBU will overheat and fail. Because of possible open cutouts and failed capacitors, it is best not to apply a CBU with a lower amperage rating in the neutral unless there is protection on the capacitor bank for unbalance current tripping. Without such protection, the CBU must be rated for the nominal line current.

### Size of Three CBUs in a Three-Phase Wye Configuration

When three CBUs are installed between the capacitors and the primary (high) side of a three-phase wye configuration, as shown in Figure 2.2 on page 7, the operating current of the CBU is calculated by dividing the size of the capacitor bank by three and dividing the resulting value by the line to ground voltage.

#### Example

This example shows how to calculate the correct size for three CBUs in a three-phase wye configuration.

1. Take the size of the capacitor bank, which is 600 kVAR (600,000 VAR) in this example, and divide it by three to determine the single-phase capacitor VAR value.

$$\frac{600 \times 1000}{3} = 200000$$

2. Calculate the current by dividing the result of step 1 by the line to ground voltage, which is 7.2 kV (7200 V) in this example.

$$\frac{200000}{7.2 \times 1000} = 27.8$$

3. The calculated current is 27.8 A. As shown in Table 1.1 on page 3, this value is below the nominal current rating of CBU style CB01PX01, which is 30 A.

**NOTE:** 30 A CBUs (CB01PX01) will work for three-phase wye configurations that are 7.2 kV or higher, if the capacitor bank is 600 kVAR or smaller.
A decrease in voltage or increase in kVAR will cause the current to increase, which will require the use of the 60 A CBU (CB02PX01) or 85 A CBU (CB03PX01).

## Size of Three CBUs in a Three-Phase Delta Configuration

When three CBUs are installed between the capacitors of a three-phase delta configuration, as shown in Figure 2.3 on page 7, the operating current of the CBU is calculated by dividing the size of the capacitor bank by the line to ground voltage.

### Example

This example shows how to calculate the correct size for three CBUs in a three-phase delta configuration.

1. Take the size of the capacitor bank, which is 600 kVAR (600,000 VAR) in this example, and divide it by three to determine the single-phase capacitor VAR value.

$$600 \times 1000 = 600000$$

2. Calculate the current by dividing the result of step 1 by the line to ground voltage, which is 12.47 kV (12,470 V) in this example.

$$\frac{600000}{12.47 \times 1000} = 48.1$$

3. The calculated current is 48.1 A. As shown in Table 1.1 on page 3, this value is below the nominal current rating of CBU style CB02PX01, which is 60 A.

**NOTE:** 60 A CBUs (CB02PX01) will work for three-phase delta configurations that are 12.47 kV or higher, if the capacitor bank is 600 kVAR or smaller.
A decrease in voltage or increase in kVAR will cause the current to increase, which will require the use of the 85 A CBU (CB03PX01).

### Size of One CBU in a Single-Phase Configuration

When a CBU is installed between the capacitor and the primary (high) side of a single-phase configuration, as shown in Figure 2.4 on page 8, the operating current of the CBU is calculated by dividing the size of the capacitor by the line to ground voltage.

#### Example

This example shows how to calculate the correct size for a single CBU in a single-phase configuration.

1. Take the size of the capacitor, which is 600 kVAR (600,000 VAR) in this example.

$$600 \times 1000 = 600000$$

2. Calculate the current by dividing the result of step 1 by the line to ground voltage, which is 12.47 kV (12,470 V) in this example.

$$\frac{600000}{12.47 \times 1000} = 48.1$$

3. The calculated current is 48.1 A. As shown in Table 1.1 on page 3, this value is below the nominal current rating of CBU style CB02PX01, which is 60 A.

**NOTE:** The 60 A CBU (CB02PX01) will work for single-phase configurations that are 12.47 kV or higher, if the capacitor is 600 kVAR or smaller.
A decrease in voltage or increase in kVAR will cause the current to increase, which will require the use of the 85 A CBU (CB03PX01).

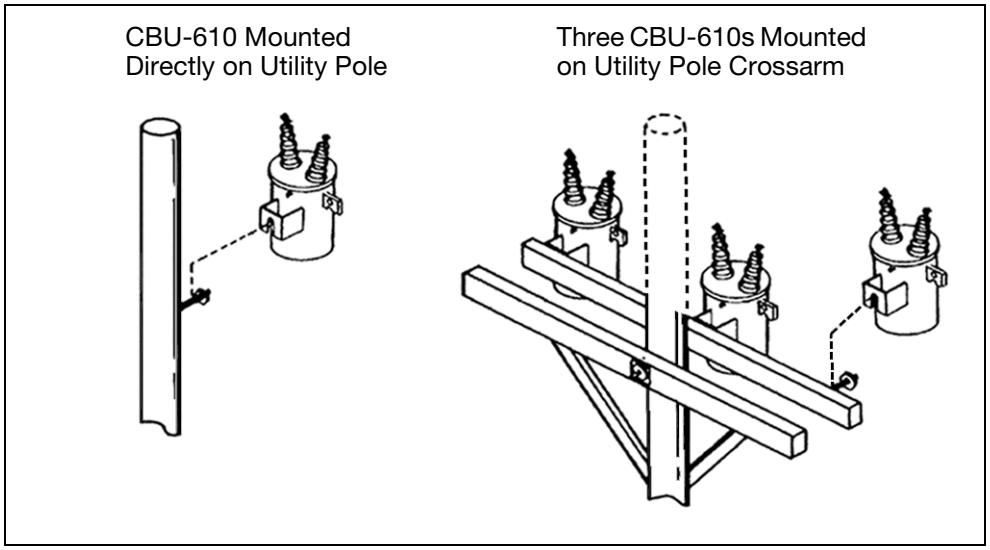
## 2.2 CBU-610 Installation Steps

Perform the following steps to install one or more CBUs:

1. Using your system implementation plan, determine the configuration of the capacitor bank and the number of CBUs to use.
2. Unpack and inspect the CBUs for shipping damage. If a CBU is damaged, submit an RMA request to Cooper Power Systems' customer service.
3. Make sure that the size of the CBUs are correct. To calculate the correct CBU size for different capacitor bank configurations, refer to "Determining the Correct CBU Size" on page 8.
4. Examine the capacitor bank location and determine how to mount the CBU(s). The CBU(s) can be mounted using one of the following methods:
   - Mount the CBU(s) directly on the utility pole.
   - Mount the CBU(s) on a utility pole crossarm.

**NOTE:** Other mounting methods that comply with utility company standards may be used.

**Figure 2.5 CBU-610 Installation Methods**




5. Using established utility company procedures, open the fused-device or optional switch (if installed).

**WARNING** Personal injury or death may result from voltage contact. The fused-device or the optional switch (if installed) must be open before any other steps in this procedure are performed. Opening the fused-device or optional switch removes the high distribution voltage from the CBU.

6. Use a hot stick to short the terminals of the capacitor bank together and to ground.

**WARNING** Personal injury or death may result from voltage contact. Using a hot stick to short-circuit the capacitor terminals to ground can cause an electrical arc at the point of contact.

7. Use the installation method selected in step 4 of this procedure to mount the CBU(s).

8. Ground the CBU by connecting a No. 6 AWG copper wire between the ground lug on the CBU and the earth ground.

**NOTE:** The utility hookup terminals on the CBU are not polarized. Either of the two terminals may interface with the two selected points on the capacitor bank circuit.

9. For each CBU, disconnect the capacitor wiring at the point where the CBU is to be installed.
10. Use copper or aluminum cables to connect the terminals of the CBU to the capacitor bank circuit, at the point where the wiring was disconnected in the previous step.

**NOTE:** The terminals can accept No. 2 through No. 8 AWG copper or aluminum cables.

11. Inspect the CBU installation to verify that each path to ground of the capacitor bank is in series with a CBU.
12. Inspect the CBU installation to verify that all work was completed in accordance with utility company standards.

**WARNING** Personal injury or death may result from voltage contact. Exercise caution while working near the CBU when the fused-device or the optional switch is closed. This closed condition applies high voltage to the CBU.

13. Close the fused-device or optional switch using established utility company procedures.

## 2.3 Testing the CBU-610 Installation

Testing the CBU-610 installation consists of comparing system performance when the CBU and associated capacitor bank are connected to and disconnected from the distribution line.

Perform the following steps to test the CBU installation:

1. De-energize the capacitor bank (all three phases) by opening the fused-device or by opening the optional switch.
2. Perform at least 10 PLC communications with a two-way device that is just down the line from the installed CBU. Record the number of successful attempts.
3. Energize the capacitor bank (all three phases) by closing the fused-device or by closing the optional switch.
4. Perform the same number of PLC communications with the two-way device used in step 2. Record the number of successful attempts.
5. Compare the results of step 2 with the results of step 4.
   - If the number of successful communications are approximately the same, the CBU performance is satisfactory.
   - If the number of successful communications decreases when the capacitor bank is energized, either one of the CBUs is malfunctioning or additional CBUs are required if this is a single CBU installed on a three-phase ground wye configuration.

     To located a faulty CBU, either replace the CBU or sequentially replace each CBU when multiple CBUs are used, and repeat the test.

## 2.4 Removing the CBU-610

The CBU-610 is not field repairable and it does not have any replacement parts. If the CBU is not working properly, it must be replaced.

**WARNING** Personal injury or death may result from voltage contact. The fused-device or the optional switch (if installed) must be open before any other steps in this procedure are performed. Opening the fused-device or optional switch removes the high distribution voltage from the CBU.

To remove the CBU, perform the following procedure using established utility company procedures:

1. Open the fused-device or the optional switch.
2. Use a hot stick to short the terminals of the capacitor bank together and the terminals of the CBU together and to ground.
3. Remove the CBU from the utility pole or substation structure.

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